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A NEW METHOD OF PRODUCING CONTINUOUSLY VARIABLE MAGNIFICATION WITH AN OPTICAL SYSTEM

GLENN A. FRY
THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION

OCTOBER 1952

WRIGHT AIR DEVELOPMENT CENTER

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A NEW METHOD OF PRODUCING CONTINUOUSLY VARIABLE MAGNIFICATION WITH AN OPTICAL SYSTEM

Glenn A. Fry
The Ohio State University Research Foundation

October 1952

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FOREWORD

This report was prepared by Dr. Glenn A. Fry of the Ohio State Research Foundation (Project 415) under United States Air Force Contract No. 33(038)15630, RDO No. 696-67, Aircraft Visual Requirements. The work was sponsored by the Aero Medical Laboratory, Directorate of Research, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, with Lt Colonel Elwin Marg acting as project officer.

ABSTRACT

A new method of producing continuously variable magnification with an optical system is described. A reciprocal function is obtained mechanically with the use of cables and pulleys.

PUBLICATION REVIEW

This report has been reviewed and is approved.

Robert H. Blount

ROBERT H. BLOUNT
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Directorate of Research

A NEW METHOD OF PRODUCING CONTINUOUSLY VARIABLE MAGNIFICATION WITH AN OPTICAL SYSTEM

The basic principle can be illustrated in the case of a single thin lens where variable magnification can be obtained by simultaneously changing the distance of the object and the distance of the screen on which the image is formed.

M and M' represent the object and the image in Fig.1, F and F' the primary and secondary focal points, and x and x' the object and image distances measured from the focal points. In order for the object point M to be imaged on the screen at M' the condition must be fulfilled that

$$-xx' = f^2.$$

In Fig. 1 the cable fastened at A wraps around pulleys at D, C, L, E, and U and is held tight by the weight at K. It is also fastened to the object M which moves with it. In a similar manner the cable fastened at B wraps around pulleys at D, C, T, G and V and is held tight by the weight H. It is also fastened to M' which moves with it. All of the pulleys are fixed except D which moves along the dashed line which lies at a distance from C which is equal to the focal length f.

When D moves, the object at M and the screen at M' both move.

If $$x = -x = -f$$

when D is located directly below C, then when D is moved to another point

$$-(x + f) = (a - f) + b \text{ or } -x = a + b,$$
$$(x' - f) = (a - f) - b \text{ or } x' = a - b$$

and $$-xx' = a^2 - b^2 = f^2.$$

Fig 2 illustrates how this method of varying magnification has been used in the design of a visual acuity meter.

The change in magnification is obtained by moving the target (M) and the Porro prism (R). Instead of changing the position of a screen to compensate for the change in image distance, the Porro prism is moved and the image remains fixed at M' which lies in the primary focal plane of lens II. Since the change in image distance is twice the movement of the Porro prism, it is necessary to introduce the pulley W, so that the movement of the Porro prism is only one-half that of the cable driving it.

The aperture at F which lies in the primary focal plane of lens I is imaged at the entrance pupil of the eye which lies at the secondary focal point S of lens II. Since the two lenses have the same focal length, the apparent angle subtended by the target at the eye is the same as the angle subtended at F and is inversely proportional to the distance of M from F.

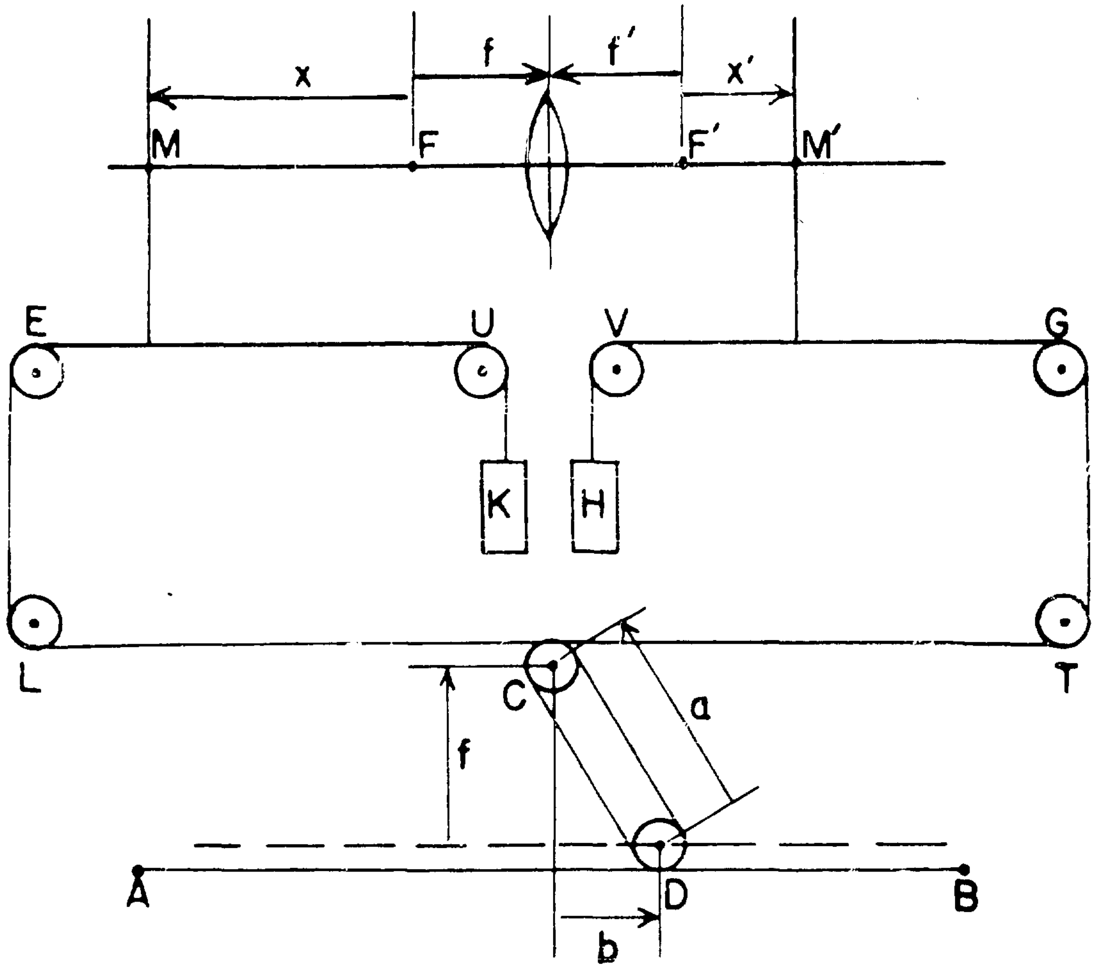

FIGURE 1

Method of Producing Continuously Variable Magnification

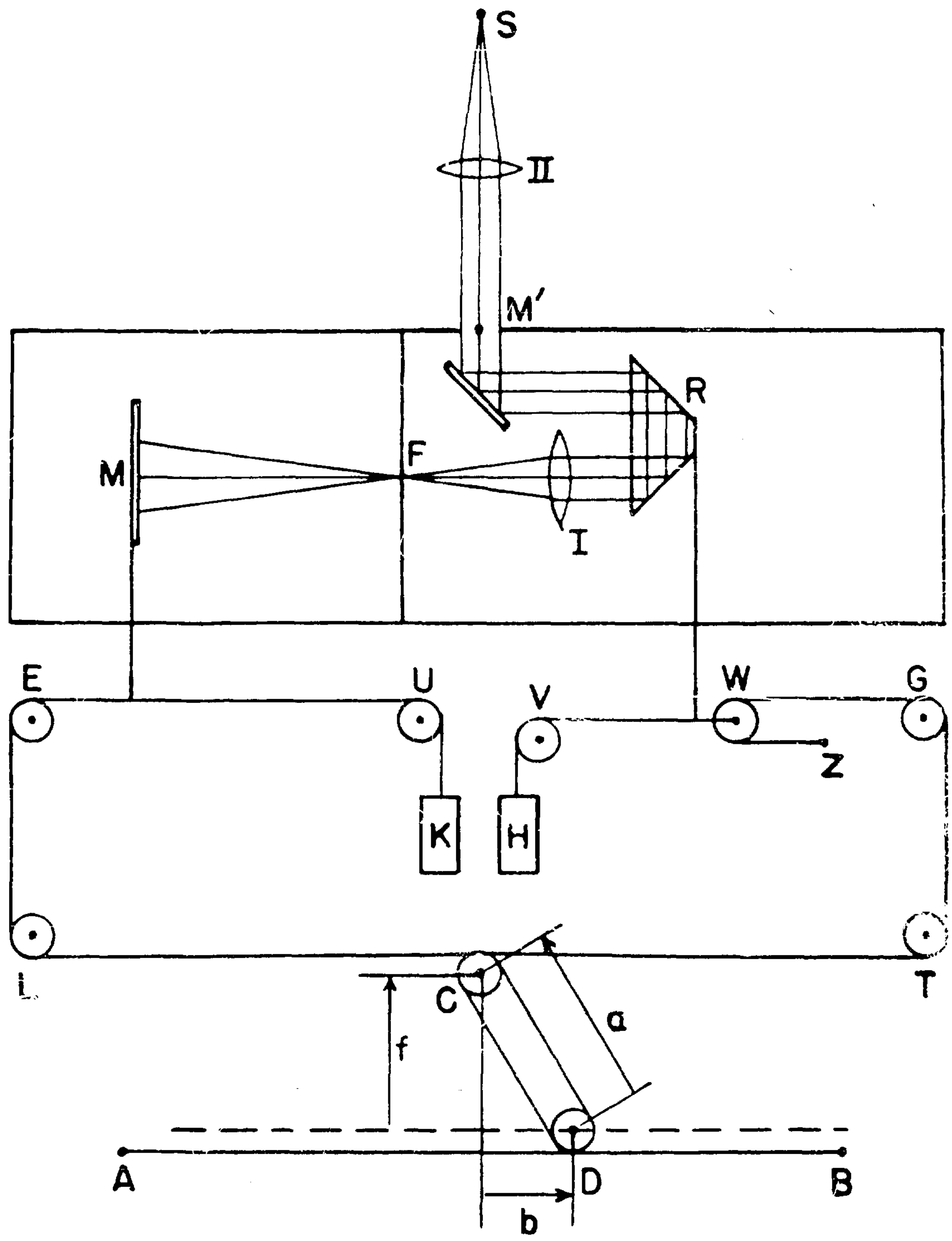

FIGURE 2

Use of Variable Magnification in the Design of a Visual Acuity Meter